Analytical Abstracts of Current Literature.

SUMMARY OF CURRENT PRE-CAMBRIAN NORTH AMERICAN LITERATURE.[1]

Ells[2] gives a description of the Laurentian of the Ottawa district. A reëxamination of the Trembling Mountain section shows that, instead of its being a continuous ascending series, there are no less than three anticlines and their corresponding synclines, and the section is still further complicated by faults of every considerable extent. But one limestone was found, that of Trembling Lake, and this instead of being interstratified with the orthoclase gneiss is in the form of a synclinal overlying this gneiss. This limestone at no point was observed to be more than 50 feet in vertical thickness.

In the region between the anorthosite area and the Gatineau river the limestone in nearly every case occupies well defined synclinals separated by anticlinals of the underlying gneiss. In this area it has been found impossible to trace any bands of limestone to any considerable distance continuously, the limestones being often local in their development, and lenticular in form.

In the limestone in certain places are masses of quartzose rock and crushed gneiss, presenting the aspect of a true conglomerate. As to the thickness of the gneiss, on the Rouge river, the most favorable place found for measurement, the section gave a thickness of 10,000 feet beneath the limestone, if there is no break, but this figure may not be accurate, as faults and repetitions of strata may occur at several places.

Intrusive within the gneiss and limestone are the anorthosite and syenite masses of Grenville and Chatham, and other less conspicuous masses. No less than six or seven clearly distinguished periods of intrusion can be recognized. The augen gneiss of the Rouge river is probably also an intrusive.

[1] Continued from Vol. I., p. 541.

[2] The Laurentian of the Ottawa District, by R. W. Ells. Bull. Geol. Soc. of Am., Vol. IV., pp. 349–360.

The succession in the district, as determined in ascending order, is (1) reddish grey gneiss without distinct signs of bedding or stratification, but with a foliated structure ; (2) reddish orthoclase-gneiss interstratified with hornblendic, quartzose, and garnetiferous gneiss and beds of quartzite, the whole showing a well stratified arrangement of beds ; (3) grayish and rusty gneiss passing gradually upward into the calcareous portion of the system, between the gneiss and the limestone there being interstratifications of the two ; and (4) schistose, sericitic, chloritic, and micaceous schists of the Hastings series. This division overlies the crystalline limestone, and is believed to represent the lower member of the Huronian system. This arrangement of the Laurentian accords very closely with that in New Brunswick, as given by Bayley and Mathew. Unconformable upon the Laurentian of Ontario is the Paleozoic.

Adams[1] describes the anorthosite of Canada, and gives its relations to the surrounding rocks. The great mass of the Archean of Canada is composed of an orthoclase-gneiss, which is in many places laminated, but is in large part little laminated, and probably of eruptive origin. Much of the laminated gneiss is probably sedimentary. In certain regions the laminated gneiss is interlaminated with crystalline limestones, quartzite, amphibolite, etc. This series is a higher part of the Laurentian, and was called by Logan the Grenville series ; while the lower gneiss, which does not bear any of this rock, was called the Ottawa gneiss. The limestone, graphite, etc., are evidences of the existence of life during the deposition of the Grenville series, and this was the earliest life of the planet.

All of the minerals of economic importance occur in the Grenville series. The relations of the Grenville series to the Ottawa series have not been certainly determined, but it is probable that the Grenville series lies discordantly upon the old gneiss, the upper series being sediments originally like those that are deposited to-day.

The anorthosite group, or Upper Laurentian of Logan, is an eruptive rock belonging to the gabbros. It is characterized by a predominance of plagioclase, which frequently is the only mineral of the rock. The rock is hard and originally was completely massive. This original structure has been modified so as to take on an extraordinary cataclastic structure, which has also given the rock a schistose character. This is not ordinary dynamic metamorphism, but is caused by a movement of the rock mass while it was deeply buried and near its melting point.

The anorthosite, although so regarded by Logan, is not a distinct sedi-

[1] Norian oder Ober-Laurentian von Canada, ADAMS, F. D. Inaugural-Dissertation zur Erlangung der Doctorwurde der Universität zu Heidelburg. 1893.

mentary geological formation, but it is discordantly upon the gneiss of the Laurentian by intrusion. Its intrusive character is shown by the following facts: it is a plagioclase gabbro; it cuts across the Laurentian schists; it holds as inclusions blocks of gneiss; about its masses forming girdles are many characteristic contact belts. The areas of anorthosite are isolated, and lie along the border of the Archean continent of that time exactly as the volcanoes of to-day are along the continental borders. In the great interior area of Laurentian no anorthosite has been found. The formation is all pre-Cambrian, as shown by the fact that it lies unconformably below the Cambrian. Also before the Cambrian was deposited it received its metamorphism, and was deeply eroded. Its relations to the Huronian have not been determined, but it probably does not belong to the Huronian period, but rather to the closing part of the Laurentian.

The several regions of anorthosite are described separately, that of Morin and Saguenay being most fully considered. The Morin area is surrounded by the Grenville series. In the Grenville series are interlaminated limestones, bands of which can be traced many miles. Within the limestone are frequently thin layers of the gneiss. The limestone is less resistant and more plastic than the gneiss. As a result of folding, the bands of gneiss have been broken up, producing irregular banded blocks, which are isolated in the limestone in such a manner as to give rise to extraordinary pseudo-conglomerates.

The Saguenay region is of great size, 5,800 square miles. It is surrounded on all sides by the orthoclase-gneiss, or Ottawa gneiss. The anorthosite of this district is more basic than that of the Morin district, the plagioclase frequently being labradorite or bytownite. That it is an intrusive is shown by the same facts as in the Morin area.

Comments.—The time of pre-Cambrian life must have been so vast that it is not safe to assume that the rocks of the original Laurentian bear the remains of the first life of the planet. Indeed, it seems probable that the earliest life left in the rocks no permanent evidence of existence. Further, before it can be assumed that the Ottawa Laurentian bears the oldest remains of life, it must be shown that these rocks are older than any other series bearing life remains.

Adams describes the typical Laurentian areas of Canada.[1] The basement rock here found is the Fundamental Gneiss. It is uniformly reddish or grayish orthoclase-bearing gneissoid granite, poor in mica, and bisilicates. The foliation is often due to movement in a plastic condition. Dark bands of amphibolite

[1] On the Typical Laurentian Areas of Canada, by FRANK D. ADAMS. Journal of Geol., Vol. I., No. 4, pp. 325–340.

are not uncommon, and hornblendic and pyroxenic gneiss appears in some places. The Fundamental Gneiss, so far as at present known, is a complicated series of rocks, for the most part of unknown origin, but comprising a considerable amount of intrusive material.

In certain parts of the Laurentian area, and notably in the Grenville district, the Laurentian has a different character. In the Grenville series the orthoclase-gneiss is still the predominating rock, although it here has a greater variety of mineralogical condition, and is frequently well foliated. Amphibolites, hornblende-schists, heavy beds of quartzite, and numerous thick bands of crystalline limestones, are all abundant and interstratified with one another. In the series are ores, and a wide variety of minerals. In the limestone and associated rocks graphite is often widely disseminated. This does not occur in the Fundamental Gneiss. The areas occupied by the Grenville series while together aggregating many thousands of square miles, are probably small as compared with those of the Fundamental Gneiss. The Grenville rocks, while generally highly inclined, over some large area are nearly horizontal, but even in these cases they have been subjected to great pressure.

As to the origin and relations of the Fundamental Gneiss and the Grenville series, three views may be taken:

1. The Fundamental Gneiss may be the remains of a primitive crust penetrated by great masses of igneous rocks and having been subjected to repeated dynamic movements. The Grenville series may be an upward continuation of the Fundamental Gneiss under altered conditions, marking a transition from a primitive crust to normal sediments. Thus the two would form one practically continuous series. The general petrographical similarity of the two series, taken in connection with the more varied nature of the Grenville series, its frequent stratified character, and the presence in it of limestones and graphite indicating an approach to modern conditions and the advent of life, together with the difficulty of clearly separating the two series from each other and defining their respective limits, lend support to this view.

2. The Grenville series may be considered as distinct from the Fundamental Gneiss, and reposing on it uncomformably, being a highly altered series of clastic origin, the Fundamental Gneiss having some such origin as suggested above or being an older series of still more highly altered sediments. As it is now thoroughly crystalline, there is, however, no absolutely conclusive proof that even the Grenville series is of sedimentary origin. However, the series is in all probability made up, in part at least, and perhaps wholly, of sedimentary material, but as this is not absolutely shown, the proposal to separate it from the rest of the Laurentian and class it as Algonkian or Huronian seems premature.

3. The Fundamental Gneiss may be considered as a great mass of eruptive rock, which has eaten upward and penetrated the Grenville series, while the Grenville series itself represents a series of altered sediments of Laurentian, Huronian, or subsequent age. The world wide distribution of the Fundamental Gneiss (forming as it does, wherever the base of the geological column is exposed to view, the foundation upon which all subsequent rocks are seen to rest) is opposed to this view, as is also its persistent gneissic or banded character.

The anorthosite series is a gabbro, often regularly laminated and much altered, which is intrusive within the Fundamental Gneiss and the Grenville series.

The Hastings series has a very local development. It consists largely of calc-schists, mica-schists, dolomites, slates, and conglomerates, thus containing much material of undoubtedly clastic origin. The whole district has been subjected to great dynamic action, some of the pebbles of the conglomerates being distorted in the most remarkable manner. This series may be equivalent to a part of the original Laurentian, may follow above the Grenville series, or may prove to be an outlying area of Huronian rocks folded in with the Laurentian.

The whole of the above series was cut by various acid and basic rocks, metamorphosed and folded before upper Cambrian time, since the Cambrian sediments rest upon them unconformably, and contain fragments of the lower series which show that when deposited they were in their present condition.

The roche moutonnée surface possessed by the eroded Laurentian rocks was impressed upon them in the first instance in pre-Cambrian times, for along the edge of the nucleus from Lake Superior to the Saguenay, the Paleozoic strata may be seen to overlie such surfaces showing no traces of decay, and similar to that exposed over the uncovered part of the area. To what extent the Cambrian, Devonian, and Silurian seas passed over the Laurentian cannot be determined, but it seems probable that in Cambrian times, a not inconsiderable part of the Archean Nucleus was under water, as shown by various outliers of these rocks. What evidence there is indicates that the area in later Paleozoic, Mesozoic, and earlier Tertiary times, was out of water, being subjected to deep-seated decay and denudation, culminating in the glaciation of Pleistocene times. These processes removed all but remnants of the Paleozoic strata.

Comments.—The question may perhaps be asked whether the visible contacts of the pre-Cambrian and Cambrian are sufficiently extensive to warrant the statement that the pre-Cambrian topography was similar to the present topography. May not the tendency to carry in imagination the present forms under the Cambrian have been given undue weight?

Lawson,[1] in 1893, on lithological grounds suggests the following hypothetical correlation of certain rocks of Western Ontario and Minnesota, Eastern Ontario and Quebec:

	WESTERN ONTARIO AND MINNESOTA.	EASTERN ONTARIO.	QUEBEC.
In order of superposition.	Ontarian system.	Hastings series.	Grenville series.
	Laurentian system.	Ottawa gneiss.	Ottawa gneiss.
	Carltonian-Anorthosites of Minnesota.		Norian.
In order of chronological sequence; an irruptive rock being of later age than the formations which it invades.	Carltonian-Anorthosites of Minnesota.		Norian.
	Laurentian system. — Batholitic granites and gneisses.	Ottawa gneiss.	Ottawa gneiss.
	Ontarian system.	Hastings series.	Grenville series.

Comments.—It seems to the reviewer that such lithological correlations between rocks in different and widely separated geological provinces have no value. The reasons for this belief cannot be here stated, but they have been published in Bull. No. 86, U. S. Geol. Survey.

Barlow[2] describes the Laurentian granites and gneisses as intrusive in the Huronian rocks north of Lake Huron. The localities described are Killarney Village; Beaver, Fox, Balsam, Three Mile, Brush, Camp, Crooked, Johnny, Panache, Wavy, Chief's, Daisy, Baby and Alice lakes; Goshen, Broder and Dell townships; Wahnapital river; Cartier and Straight Lake Stations; and two islands near Thessalon. As evidence of the eruptive nature of the Laurentian gneiss in the Huronian sediments are cited the diverse stratigraphic relations of the rocks along their line of junction; the invariable alteration of the sedimentary rocks along the contact line; the inclusion of angular fragments, clearly referable to the adjacent sedimentary strata in the gneiss; the occurrence of gneissic intrusions and apophyses of pegmatite, occurring in or lam-

[1] The Norian Rocks of Canada, by A. C. LAWSON. Science, Vol. XXI., No. 538, pp. 281–282.

[2] Relations of the Laurentian and Huronian Rocks North of Lake Huron. By A. E. BARLOW. Bull. Geol. Soc. of Am., Vol. IV., pp. 313–332.

inated with, and cutting across the bedding of the Huronian rocks; the absence of sedimentary rocks within the gneiss, and the general character of the gneiss, which in appearance and behavior more nearly resembles an eruptive granite than an altered sedimentary rock. It is therefore concluded that the Huronian is the oldest series of sedimentary strata in this region, and that the floor upon which these were lain down must have been subsequently fused and recrystallized.

Comments.—That in many localities there are granites and gneissoid granites intrusive in the Huronian of Lake Huron has been well known since the days of Logan. However, because a part of the granites are intrusives later than the Huronian, this does not show that the basement upon which the Huronian was laid down does not still exist, in part at least, as held by Logan, Irving, Pumpelly, and others. The account of the facts and their interpretation at the contacts near Thessalon by Barlow are so irreconcilable with those given by Pumpelly, Irving, and myself, that the former or the three latter must have wholly failed to grasp the truth. These latter hold that there is here the most manifest evidence of profound unconformity between the Basement Complex and the Huronian. Should this position prove correct, the question would naturally arise as to what extent the accounts of the remaining localities described by Barlow need revision.

Smith,[1] in 1893, gives a general description of the Archean rocks in the southern half of the Rainy Lake district in the Province of Ontario, between the Thunder Bay district and the Lake of the Woods. The rocks here found are divided into the Lower Archean and Upper Archean, the term Archean being defined to include all pre-Cambrian rocks. The Lower Archean series, or Laurentian, comprises a lower granitic and syenitic division, and an upper micaceous, hornblendic and trappean division, for the most part schistose. The first usually occurs in rounded or ovoid areas, between which are the rocks of the Upper Archean or Ontarian.

The Ontarian system includes the Contchiching and Keewatin series. The Contchiching rocks are mainly mica-schists, and have an estimated thickness of 9,000 feet, the apparent thickness of 24,000 to 29,000 feet, given by Dr. Lawson, being believed to be due to multiple folds. These mica-schists are regarded as clastic in origin, because of their fine and even lamination. The Keewatin consists for the most part of plutonic, volcanic, and pyroclastic rocks, although in some of the upper members there are more or less aqueous sediments. The Contchiching and Keewatin are everywhere in strict conformity, although at the base of the Keewatin in certain localities there are conglomerates regarded as local and volcanic.

[1] The Archean Rocks West of Lake Superior. By W. H. C. SMITH. Bull. Geol. Soc. Am., Vol. IV., pp. 333–348.

The Laurentian granites and gneisses are intrusive in the Ontarian, and are therefore younger, the relations between the two being the same as described by Lawson in the Rainy Lake district.

Resting discordantly upon the Laurentian and Ontarian rocks, is the Steep Rock series, presumably of Archean age. This series is believed to be a folded syncline, rather than a monocline, as described by Smyth. As the Animikie series exhibits no such folding, the inference is strong that the Steep Rock series is older than the Animikie. While the unconformity between the Steep Rock series and Laurentian is undoubted, the unconformity between the Keewatin of the Seine river and the Steep Rock Lake series is not at all obvious. Lithologically the two series are strikingly similar, and could not be separated by the most careful study. It would seem that to the west of Steep Rock Lake this series has been faulted up and swept away, so that it is really unconformably above the Keewatin. The Atic Oban series is an eruptive one probably belonging to the Keewatin.

Comments.—Since the Steep Rock Lake series is almost identical in character with the Keewatin, the assumption of profound faulting and erosion to explain the absence of the former series west of Steep Rock Lake seems purely gratuitous, the natural explanation being that the two are the same, and that the discordance at the base of the Steep Rock series is marked in other localities by the occasional conglomerates described by Lawson and Smith at the base of the Keewatin. That unconformities are partly obliterated or difficult to discover when the discordant series are closely folded is well known, and that a break, if such exists at the base of the Keewatin, should be so strongly marked everywhere as at Steep Rock Lake could not be expected. A conglomerate in itself is of course no evidence of unconformity, but the conglomerates at the base of the Keewatin are of such a character that Dr. Lawson, who has studied the district, believes that they mark, if not a real unconformity, a profound change of physical conditions between the Contchiching and Keewatin. Also he holds that these conglomerates are sedimentary, rather than volcanic.

Fine and even lamination, it may be said, is not sufficient evidence that the rocks showing this structure are clastic. Such structures are found both in metamorphosed igneous and sedimentary rocks. Moreover, it cannot be assumed that such a structure corresponds with bedding, even if the rocks are clastic. Hence, until it is shown that the two do correspond, determinations of thickness based upon lamination can have little value.

Buell[1] describes and maps the Waterloo quartzite areas. These are a series of detached outcrops resting unconformably under the Lower Silurian

[1] Geology of the Waterloo Quartzite Area. By I. M. BUELL. Trans. Wis. Acad. Sci., Vol. IX., pp. 255–274.

of Southern Wisconsin. Within the quartzite are occasional layers of conglomerate. The different outcrops are apparently parts of a synclinal fold. As a result of the shearing much of the quartzite has been crushed, and sericite has developed.

Van Hise[1] considers the dynamic phenomena shown by the Baraboo quartzite ranges of Central Wisconsin. These rocks, indurated by cementation, exhibit all stages between massive quartzite showing microscopically little evidence of interior movement, through a rock having in turn fracture and cleavage, to one which is apparently a crystalline schist, but in thin section still giving evidence of its fragmental origin. The schistosity produced by the movement of the layers over one another is parallel to the bedding. In places *Reibungs* breccias have developed. At one point minor faulting was noticed. These phenomena are more marked in the North Range than in the South Range, and thus bear in favor of Irving's explanation of the structure as a part of a single great fold in a set of layers 12,000 feet thick, the North Range being on the leg of the fold, and thus requiring greater readjustment of the beds than those on the South Range, which are near the crown of the anticline.

Winslow,[2] in 1893, places in the Archean the granites, porphyries, and felsites of Missouri, and in the Algonkian the associated conglomerates, one of them bearing the Pilot Knob iron-ore.

Keyes,[3] in 1893, holds that the granites of Maryland are eruptive, since these rocks indiscriminately cut across the other igneous rocks of the region, as well as the gneiss ; because they hold inclusions of the other rocks of the region ; because the rocks cut show contact phenomena, and because a microscopical examination shows that they possess all the characters of rocks cooled from fusion.

Smyth,[4] in 1893, describes the rocks of Gouverneur, N. Y. The gneiss gives evidences of mechanical deformation in the shattering of the quartz and

[1] Some Dynamic Phenomena Shown by the Baraboo Quartzite Ranges of Central Wisconsin, by C. R. Van Hise. Journ. of Geol., Vol. I., No. 4, pp. 347–355.

[2] The Geology and Mineral Products of Missouri, by ARTHUR WINSLOW. From "Missouri at the World's Fair." (Official Publication of the World's Fair Commission of Missouri).

[3] Some Maryland Granites and Their Origin, by C. R. KEYES. Bull. Geol. Soc. of Am., Vol. IV., pp. 299-304.

[4] Petrography of the Gneisses of the Town of Gouverneur, N. Y., by C. H. SMYTH, Jr. Contributions from the Geol. Dept. of Columbia College. Reprinted from Transactions of the New York Academy of Sciences, Vol. XII., pp. 203–217.

feldspar particles. Within the feldspar, along the cracks, microperthite has developed which does not show any dynamic action. The granite is much later than the gneiss, but like it has to some extent suffered from dynamic action. In general it is massive, or nearly so, but there are zones of shearing where granulite and gneiss have developed. Also in one portion there is a dark rock approaching a diorite, into which the granite grades, but this is regarded as a basic segregation from the original magma. The crystalline limestone is rather uniform in its character, but where intruded by the granite, it is more coarsely crystalline, and various metamorphic minerals have developed. Near the base of the limestone is a pyroxenic rock which is schistose, highly contorted, and is of somewhat doubtful origin, in the field being regarded as sedimentary, and under the microscope having an appearance which suggests an igneous origin. In this pyroxenic gneiss occasionally scapolite is found. The Potsdam is a pure vitreous quartzite, indurated by the process of cementation.

Nason,[1] in 1893, describes the gneissic rocks bearing iron-ore in the Adirondack region as precisely like the Mt. Hope type of rock, bearing the New Jersey magnetites, and it is thought that the two are probably contemporaneous, bedded deposits. These gneissic ores are non-titaniferous, and are to be discriminated from the titaniferous iron ores which are associated with the labradorite rocks or norites of the region. These in occurrence and association are wholly distinct from the ores belonging in the gneisses.

Lawson[2] describes the Santa Lucia granite of Carmelo Bay as resting unconformably below the sedimentary rocks (Miocene) of the Carmelo series. At the base of the latter is a fine basal conglomerate. Across the Bay of Monterey, in the Santa Cruz range, granite without doubt of the same geological range bears a similar relation to rocks which are of not later age than Cretaceous. The granite is therefore, at the latest, of pre-Cretaceous age.

C. R. VAN HISE.

[1] Notes on Some of the Iron-bearing Rocks of the Adirondack Mountains, by F. L. NASON. Am. Geol., Vol. XII., No. 1, 1893, pp. 25–31.

[2] The Geology of Carmelo Bay, by A. C. LAWSON. Bull. Dept. Geol., Univ. of Cal., Berkeley, Vol. I., pp. 1–59.